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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Herbage Production Differs with Soil[1] in the Pinyon-Juniper Type of Arizona

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Field observations and field data show that production on Springerville soils is similar to production on Gem and Tortugas soils where there are few pinyon and juniper trees, but that the Springerville soils produce much less perennial herbaceous vegetation than the other soils when there is appreciable tree cover. From the behavior of the species studied, the differences in the soils observed in the field did not appear to be due to soil moisture, nitrogen, or phosphorus.

One of the major problems of the pinyon-juniper type is the low herbage production as a result of tree overstory. Increased tree cover results in reduced understory production: tree covers of 10 percent and 30 percent have reduced herbage production 40 percent and 65 percent, respectively.[4] An examination of the Gem, Springerville, and Tortugas soils indicates that trees affect herbaceous vegetation differently on those soils. This Note presents results from an examination of nutrient status of these soils as a factor contributing to the differential responses of the soils to tree cover.

[1]*Soil profile descriptions in this study were made by George Wendt and Mack L. Miller, U. S. Soil Conservation Service, and Truman Anderson and W. R. Mitchell, U. S. Forest Service.*

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[4]*Arnold, Joseph F., Jameson, Donald A., and Reid, Elbert H. The pinyon-juniper type of Arizona: Effects of grazing, fire, and tree control. U. S. Dep. Agr. Prod. Res. Rep. 84, 28 pp., illus. 1964.*

The Soils

About 32 percent of the pinyon-juniper type of Arizona is on soils formed from basalt parent material. Much of this parent material has developed into Gem and Springerville soils. An area of similar size (29 percent) is underlain by the Kaibab and Redwall limestones, much of which in turn has developed into Tortugas soils.

Gem.—This series is developed from basalt and other volcanic materials. It is the only soil in this study with a B horizon. In our samples, the average thickness of the solum (A and B horizons) was 15 inches, and the total soil depth 26 inches. The average texture was a clay loam on the surface layer and clay (49 percent clay) in the B horizon.

Nomenclature requirements may cause the name of this series to be changed to "Thunderbird."

Springerville.—These heavy clay soils have developed from parent materials that are, superficially at least, the same as the parent materials of the Gem series. The Springerville soil, however, is a vertisol, and soil churning is evident. Because of the churning effect, there is a lack of profile development. These soils have been described in detail by Johnson et al.[5] In our samples, the clay content below the surface averaged 55 percent, and soil depth averaged 34 inches.

Tortugas.—These are shallow, skeletal soils from limestone. In our samples the A horizon averaged 8 inches thick. Clay content on the surface averaged 24 percent, and this increased to 28 percent in the C horizon.

Soil chemicals were determined by "La Motte" soil tests (table 1). The major difference between these soils was the calcium content, ranging from 11,667 p.p.m. for the Tortugas soils to 4,650 for the Springerville soils.

[5] *Johnson, W. M., Cady, J. G., and James, M. S. Characteristics of some brown grunosols of Arizona. Soil Sci. Soc. Amer. Proc. 26: 389-393. 1962.*

Table 1.--Chemical analysis of three soils of the Arizona pinyon-juniper type

Soil series	Samples	Analysis								
		P_2O_5	K_2O	NO_3	NO_2	NH_3	Ca	Mn	Al	Fe
	Number	- - - Pounds per acre			- - -		p.p.m.			
Tortugas	4	183	177	9.3	[1]VL	VL	11,667	ML	ML	L
Gem	6	183	186	10.2	VL	VL	6,167	L	ML	L
Springerville	7	186	184	4.6	VL	VL	4,650	L	M	L

[1]VL = Very low; L = Low; ML = Medium to low; M = Medium.

Table 2.--Field production of three soils of the Arizona pinyon-juniper type

Soil series	Locations	Plots	Tree canopy	Herbage weight[1]		
				Perennials	Annuals	Total
	- - Number	- -	Percent	- - Pounds per acre - -		
Tortugas	2	6	[2]0	542	5	547
Gem	3	17	[2]3	457	0	457
Springerville	3	11	[2]3	517	22	539
Gem	1	48	[3]16	128	0	128
Springerville	2	92	[3]19	25	35	60
Tortugas	1	49	[3]31	80	6	86
Gem	1	49	[3]29	93	0	93

[1]Includes all herbage, but composition was primarily grasses.

[2]Tree canopy was from 50-foot line intercept transects (see Canfield, R. H., Application of the line interception method in sampling range vegetation. J. Forest. 39: 388-394. 1941.). Herbage weight was from corresponding 4-inch by 50-foot belts. Only total herbage weight was determined; the proportion of weight between annuals and perennials was estimated on the basis of relative basal area contribution.

[3]Tree canopy was from a spherical densiometer (see Lemmon, P. E., A spherical densiometer for estimating forest overstory density. Forest Sci. 2: 314-320. 1956.). Herbage was from corresponding 9.6-square-foot circular plot. Weights of annuals and perennials were determined separately.

Field Production

Field observations of these soils impress the observer with the lack of herbage production under pinyon-juniper stands on Springerville soils, although there is less difference between soils where there are few trees (fig. 1). Data from several study plots bear out these observations (table 2). These plots were selected for presentation here because the understory vegetation was primarily grasses and forbs. The production figures for grasses, therefore, are not confounded by competition from shrubs and half-shrubs. On plots with few or no pinyon or juniper trees, there was less than 20 percent difference in the herbage production on the three soils studied. Even with about 30 percent tree cover there was little difference in production between the Gem and Tortugas soils. With 19 percent tree cover, however, the Springerville soil produced only 47 percent as much as Gem soil with 16 percent cover. Much of the production on the Springerville plots with tree cover was from annuals, while on the other plots nearly all of the herbaceous production was from perennials.

Figure 1.--Study plots on three soils in Arizona, and related tree cover.

Springerville soil series,
tree cover, 0.7 percent

Springerville soil series,
tree cover, 19 percent

Gem soil series,
tree cover, 29 percent

Tortugas soil series,
tree cover, 31 percent

Greenhouse Production

To study the productivity of these soils under uniform conditions, soil samples from 17 locations were brought into the greenhouse for pot tests. Soil samples included the upper 10 inches of soil. The samples were screened through a 2 mm. screen, and 1,500 grams of air-dry soils were placed in polyethylene pots of about 3-quart capacity. All pots were brought to field capacity with distilled water, and twice weekly during the study soils were watered to restore the field capacity weight. Six pots of soil from each location were planted with corn, and six with side-oats grama (Bouteloua curtipendula (Michx.) Torr.). Side-oats grama was selected as a representative native plant, and corn was selected because some nutrient deficiencies are easily recognizable. After the seeds had germinated, the number of plants in each pot was reduced to one.

When the plants appeared to be well established, 75 mg. nitrogen (in NH_4NO_3) was added to one-third of the pots, and nitrogen plus 75 mg. P_2O_5 (in $Ca(H_2PO_4)2H_2O$) to another third. The pots were arranged in the greenhouse in two replications.

After 7 weeks, the corn plants were harvested, ovendried, and weighed (table 3). The side-oats grama was harvested at 9 weeks. In spite of the generally high phosphorus content of these soil samples, the corn plants commonly showed phosphorus deficiency symptoms; these symptoms were not altogether relieved by addition of phosphorus. There was, in fact, a significant negative correlation ($r = -0.683$, 15 df) between the calcium content of the individual samples and the increase of the NP treatment over the N treatment. This was apparently due to the high calcium content resulting in insoluble forms of phosphorus.

The Gem samples were the highest producers in all categories except for unfertilized corn. The Springerville samples were the lowest producers for corn, but the Tortugas samples were the lowest producers for side-oats grama. All soils showed response to nitrogen fertilizer. The greatest response to nitrogen fertilizer was on the Gem soils; additions of fertilizer to the other soils did not reduce the difference between these samples and the Gem samples.

Summary and Conclusion

Field observations and field data show that production on Springverville soils (vertisols) is similar to production on Gem and Tortugas soils when there are few pinyon and juniper trees, but that the Springerville soils produce much less perennial herbaceous vegetation than the other soils when there is appreciable tree cover. Production of corn and side-oats grama on samples of these soils kept at field capacity in the greenhouse showed differences between the series, with the Gem samples being the most productive. The difference between the soils was increased rather than reduced by addition of nitrogen and phosphorus fertilizer. From the behavior of the species studied, the differences in the soils observed in the field did not appear to be due to soil moisture, nitrogen, or phosphorus.

Table 3.--Corn and side-oats grama produced in greenhouse tests of three soils of the Arizona juniper type with three fertilizer treatments

Soil series	Corn				Side-oats grama			
	No fertilizer	N added	N+P added	Mean	No fertilizer	N added	N+P added	Mean
	Milligrams per pot							
Tortugas	825	1,838	1,650	1,438	44	51	49	48
Gem	692	2,192	2,408	1,764	75	166	139	127
Springerville	442	1,142	1,464	1,016	52	59	90	67
Mean	653	1,724	1,841	1,406	57	92	93	81